MOST Project COLY CODE NUSC/NL Problem No. 00-00-101mm SF 11 552 001-11282 4DA 0 35 8 NAVAL UNDERWATER SYSTEMS CENTER LISTENING SYSTEM . DiRienzo NUSC/NL-NUSC/NL-Techni ₩ No. 2212-23-71 INTRODUCTION The New London Laboratory of the Naval Underwater Systems Center (NUSC/NL) and the Air Force Eastern Test Range (AFETR), at Patrick Air Force Base, Florida, have jointly funded the design, fabrication and installation of a Broad Band MILS Littening System off the south coast of Bermuda. The effort is for an acoustic receiver for missile impact location and splashdown on the ccean surface and for detection of underwater explosions via the SCFAR channel. The system also is an acoustic research tool for the Naval Underwater Systems Center. DISCUSSION The Broad Band Listening System is implanted approximately six nautical miles south of Bermuda at a geographic location of 320 08' 41" N and 64° 50' 43" W, is positioned by a Decca Hi-Fix Navigational System An acoustic ADMINISTRATIVE INFORMATION This memorandum was prepared under NUSC/NL Project Title: Underwater Sound Propagation Studies, W. Thorp and W. Schumacher, Principal Investigators. The Sponsoring Activity was NAVSHIPS COV1, J. Reeves, Program Manager. DISTRIBUTION STATEMENT A Amproved for public release; Distribution Unlimited

transponder was also attached to the anchor cable for acoustic location at a later time. The system consists of two assemblies (upper and lower). The upper assembly is buoyed 3,050 feet above the ocean floor at a depth of 4,030 feet. The lower assembly is at a water depth of 4,530 feet. Each assembly consists of two hydrophones, one temperature sensor, one current speed rensor, one current direction sensor, one electronic package and one pressure housing. An assembly as viewed before pressure testing is shown in Figure 1. The assemblies provide acoustic receivers in the SOFAR channel for long range propagation studies. They also provide for a Missile Impact Location System (MILS) at Bermuda. Other useful applications are ambient noise studies, attenuation measurements, bottom loss studies and biological and shipping noise. The environmental sensors provide a means of long term correlation studies of temperature and current variations with acoustic propagation phenomena.

## SYSTEM DESCRIPTION

The assemblies have 3.050 feet of 4-conductor riser cable, seven nautical miles of 4-conductor sea cable (Dalton) and a splice to the final 4-conductor sea cable to the Naval Underwater System Centers Tudor Hill Laburatory. The electrical connections of the assemblies are made through D. G. O'Brien double "O" ring protected connectors. The assemblies were temperature and pressure tested (to 2,000 psi) prior to implantment.

The acoustic receivers, as shown singularly in Figure 2, were made by NUS Corporation of Paramus, New Jersey. They are the High Reliability Deep Sea Hydrophones Model 1125. These hydrophones have a life expectancy of five years with less than  $\pm 0.5$  db change in sensitivity for a two year period. The sensitive element is made of lead-metaniobate and its calibration is traceable to the bureau of standards. The hydrophone has a flat (+1.0 db) and omnidirectional frequency response from 10 Hz to 5 KHz and is useable to 10 KHz as depicted in Figures 3 through 6. The : self-contained preamplifier has a fixed gain of 20 db and self noise characteristics such that detection of zero sea state is possible to frequencies of 5 KHe. An internal 10 n precision resistor permits an in-situ calibration feature. The hydrophone case is made of a titanium alloy for maximum resistance to salt water corrosion. The active element is double rubber booted for minimization of salt water migration. The space between the boots is oil filled and contains a metal shield for strength and reduction of pickup from extraneous fields. The output of the preamplifier feeds a low output impedance cable driver. The pressure case is attached to the associated 4-conductor FSS-2 cable through a neoprene mold.

The temperature probe, shown in Figure 7, is made by Gulton Industries, and is a Model MET-2. The probe is basically a two wire device for

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measuring liquid temperatures over the range of  $-5^{\circ}$  C to  $\pm$  40° C to an accuracy of 0.025° C. The sensor consists of piezoelectric elements which cause a change in their natural resonant frequency when the temperature of the element itself changes. The output signal is a constant amplitude varying frequency signal directly proportional to the temperature. The probe contains a water-tight Marsh and Marine connector type XSG-2-BCL. The DC power and AC signal are on the same wire so that decoupling between the power supply and signal is required. The unit has an antifoulant shield constructed of a glass based epoxy, which inhibits adherence of sea life to the sensing surfaces. The thermal time constant of the unit is typically fifteen seconds. The output frequency varies over the range of 10kC to 75kC yielding a sensitivity of nominally 1kHz/°C. The calibration data for both temperature sensors is shown in Table 1, sheets I through 6 inclusive. The resolution is 0.001°C for a one second gate time and may be increased tenfold by using a ten second gate time. It should be noted that interpolation between data points can be utilized, but the accuracy limit should be borne in mind.

The underwater speed sensor, Model 460, shown in Figure 8, is made by Hydro Products. The unit is a precision balanced, high impact polystyrene Savonius rotor mounted on carbide self-cleaning bearings. All metal parts are made of 304 stainless steel for maximum resistance to the corrosive ocean environment. The operation of the unit is as follows: water movement past the underwater sensor rotates the Savonius rotor at an angular rate proportional to the speed of the water flow. There are ten magnets imbedded into the polystyrene and a magnetic reed switch mounted in the vicinity for sensing. The output signal is therefore ten closures per revolution. A calibration curve for both units is shown in Figure 8A. The curve represents sensor speed in knots as a function of rotor output in magnetic switch closures per second.

The current direction sensor is also made by Hydro Products. It is their Model 465-A and is shown in Figure 9. The sensor consists of a balanced free-swinging plastic vane which is magnetically coupled to a micro-torque potentiometer and compass assembly located in the housing. All metal parts, with the exception of the main housing of brass, are made from 304 stainless steel. The static error has been reduced by giving special consideration to internal bearing design to minimize compass and potentiometer loading. The sensor is oil-filled and pressure equalized so that operation at any depth is possible. The linear potentiometer is referenced to a viscous damped, magnetic compass rather than to the case. As a result, directions indicated are relative to magnetic north irrespective of the Sensor orientation. The sensor has a linearity of  $\pm 0.35^{\circ}$ , calibration accuracy of  $\pm 5^{\circ}$  and a useful range of  $\pm 50^{\circ}$ . The electrical penetrators are male bulkhead connectors which are

in turn, molded into a jumper cable to the D. G. O'Brien connector on the pressure case.

The pressure case shown in Figure 10 contains all the electronic components necessary for switching, balanced operation and calibration of the system. The pressure housing is made of 316 stainless steel and was designed to withstand 7,500 psi. The case contains four bulkhead connectors, D. G. O'Brien type, with two located in each end cap. One end cap receives the two hydrophone input cables while the other contains the sensor cable and the output connection. The pressure case has both radial and facial "O" ring seals for maximum protection from the ocean environment. The housing also has two ounce desiccant bags and was filled with nitrogen before scaling to prevent the formation of condensation on the walls and electric components. The electronic components are shown in Figure 11. The components are mounted on phenolic wafers and contain the calibration oscillators, decoupling circuits, switching components, transformer for balanced operation, voltage controlled oscilpower supply regulators. The hydrophone cables are coupled to the electronics and built in redundancy is used in the event a failure should occur to one hydrophone unit. The current direction sensor is supplied with a regulated 4.7 VDC across its potentiometer. The swinger is coupled to a VCO in IRIG Band 13. IRIG Band 13 has a center frequency of 14.5 KHz and a bandwidth of 2176 Hz. The output signal from the VOO is a constant amplitude varying frequency signal, proportional to the current direction. A calibration curve is shown in Figure 12. The current direction signal is coupled to the current speed sensor output to the transformer for transmittal to the shore facility at Tudor Hill Laboratory. Since the output signal for the direction sensor is fed through the speed sensor circuit, the result is that we have an amplitude and frequency modulated signal. The frequency of the amplitude modulation is proportional to the current speed while the carrier frequency itself contains the direction information. There are five discrete frequency oscillators in the electronics package at 300, 750, 1500, 3000 and 6000 He, respectively. The amplitude of each oscillator is preset at :4.2 millivolts. The signals are linearly mixed and coupled to the 10 ohm calibration resistor for system response curves. The temperature has its decoupling circuits and the output signal coupling network in the electronics package. An electrical schematic is shown in Figure 13.

#### SYSTEM OPERATION

Each assembly has its own power supplies and control panel for independent operation. Since the operation of both assemblies is identical, only one will be discussed. Each assembly has its own cable pair in the quad sea cable. There are two modes of operation.

Mode 1. Mode 1 selects one hydrophone unit only. Application of 30 volts at 10 milliamps turns the unit on. This mode would lend itself to ambient noise measurements and propagation measurements, since no filtering is needed at the shore facility. The calibration power (57 volts at 50 milliamps) may be applied to plot a system response curve. This curve is dependent upon the termination used but an absolute calibration is possible for any load. The calibration levels preset to 4.2 millivolts and the open circuit crystal response curves enable one to generate a terminal sensitivity curve in the standard manner. The control panels contain all the decoupling and balancing components for effective system operation.

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Mode 2. Selection of mode 2 will energize a redundant hydrophone, the temperature sensor, and the current speed and direction sensors. The power requirement for these units is 82 volts at 90 milliamps. The hydrophone signal may be separated from the environmental sensors by amplification and suitable low pass filtering. The temperature sensor signal is reparated by high pass filtering, while band pass filtering and amplification is used to recover the current sensor data. A calibration feature is also selectable in this mode and operates exactly as mentioned previously. Listed in Table II are the serial number, manufacturer and system mode for all sensors in each assembly.

#### **CONCLUSIONS**

The requirement for a deep sea listening system has been met. In addition, environmental sensors have been provided for long term correlation studies with acoustic information. The built in redundancy and high reliability components should provide a long term acoustical listening system for future experiments in the SOFAR Channel, MILS and propagation runs.

### **ACKNOWLEDGMENT**

The author is grateful for the assistance and cooperation provided by T. Cummings and his associates for successful implantment and splicing requirements. Thanks are also extended to R. Smith for system development and design checking and C. Doherty for testing and evaluation.

L. F. DIRIENZO



Fig. 1

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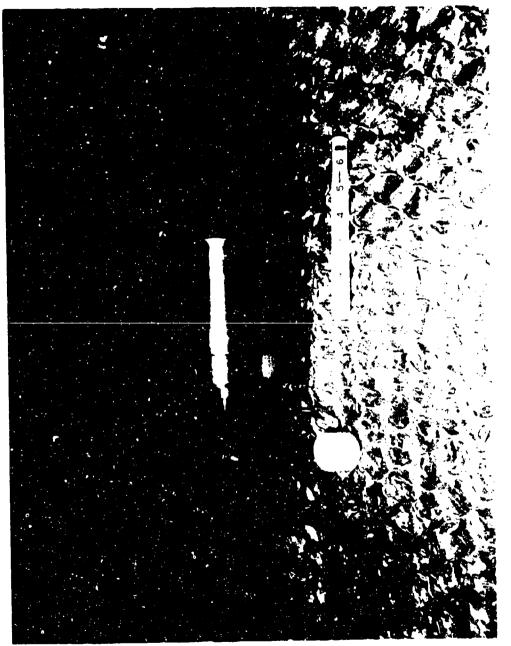


Fig. 2

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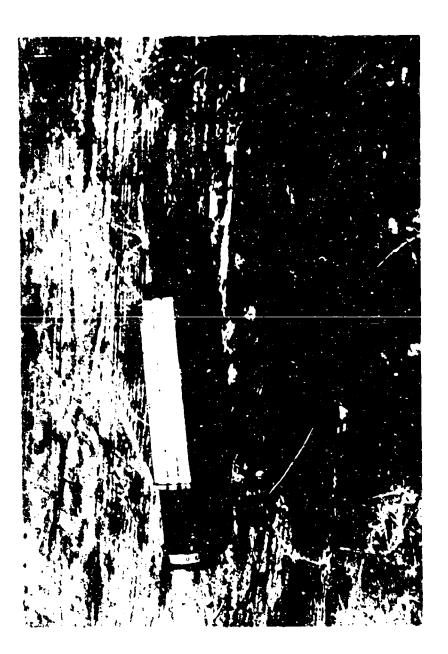


Fig. 7

NUSC, New London Laboratory NP24 - 40151 - 1 - 71

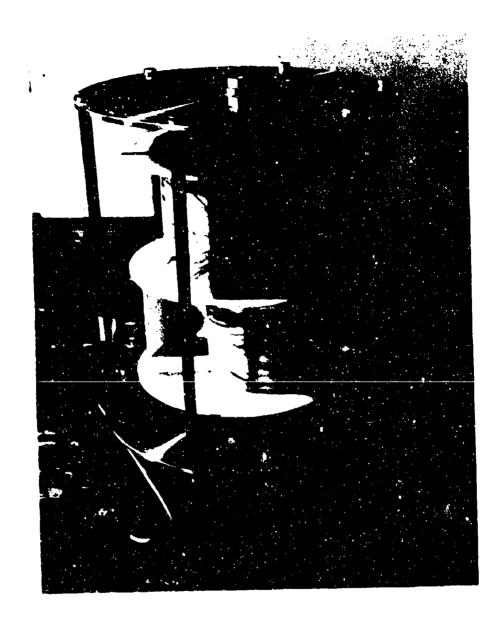


Fig. 8

NUSC, New London Laboratory NP24 - 40149 - 1 - 71

# MODEL 460 CHRRENT SPEED SENSOR

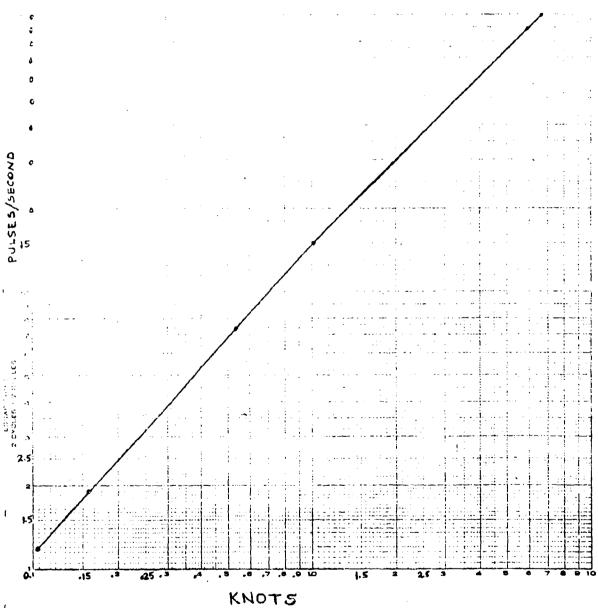


FIGURE 8A

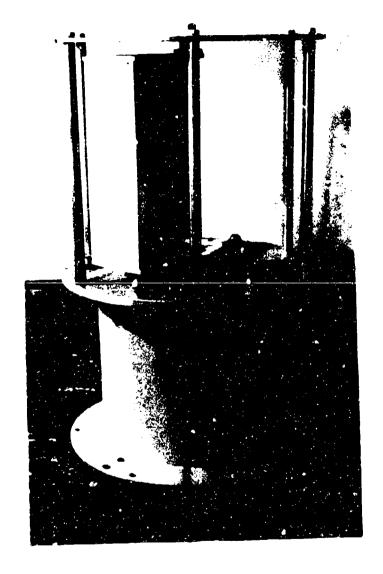


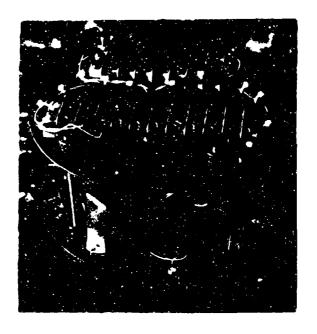
Fig. 9



Fig. 10

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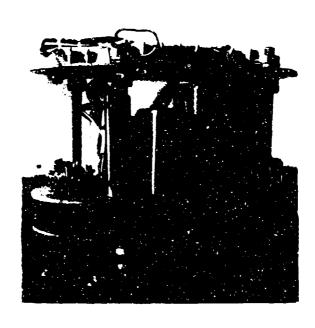


Fig. 11

NUSC, New London Laboratory NP24 - 40152 - 1 - 71



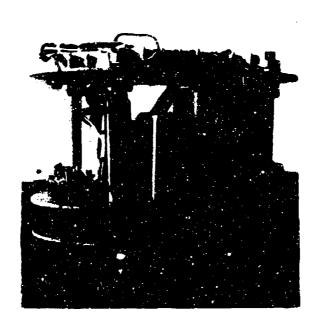
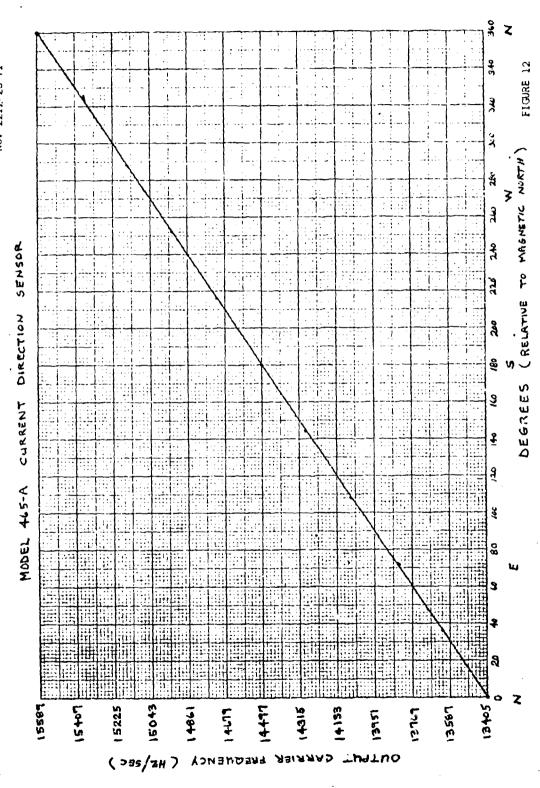
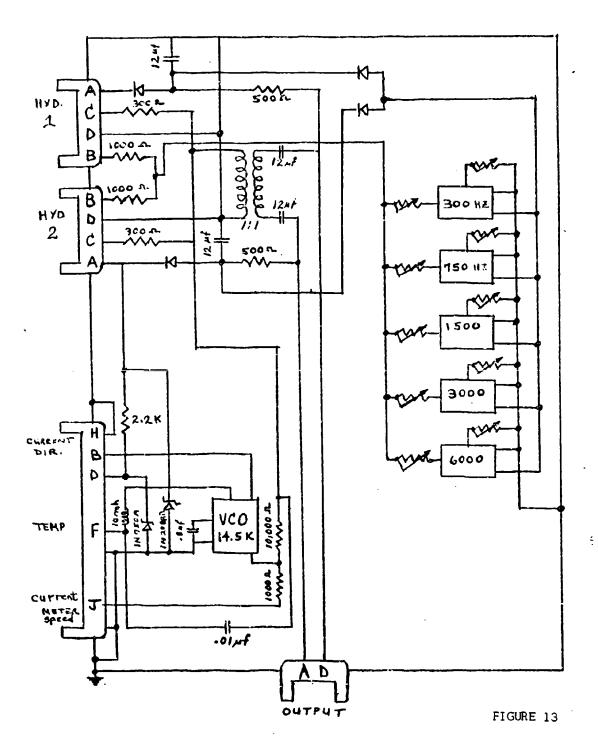


Fig. 11

NUSC, New London Laboratory NP24 - 40152 - 1 - 71

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6         20936         20945         20963         20971         20989         2           7         21024         21050         21059         21068         21076         2           8         21120         21129         21129         21138         21146         21164         2           9         21111         21120         21225         21234         21243         21164           9         21199         21206         21225         21234         21251         2           9         21199         21206         21236         21236         2         2           1         21374         21333         21330         2         2         3         3           1         21374         21333         2         2         2         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3 <t< td=""><td>٠</td><td>20849</td><td>20858</td><td>20866</td><td>20ċ75</td><td>20884</td><td>20893</td><td>20901</td><td>20910</td><td>61602</td><td>60400</td></t<>	٠	20849	20858	20866	20ċ75	20884	20893	20901	20910	61602	60400
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TABLE II

-	UPPER	UPPER ASSEMBLY		
Unit Type	Manufacturer	Serial#	Mode1#	Utilization
Hydrophone 1	NUS Corporation	1419	1125	Mode 1
Hydrophone 2	NUS Corporation	1417	1125	Mode 2
Temperature Probe	Gulton Industries	27356	MET-2	Mode 2
Current Speed Sensor	Hydro Products	659949	460	Mode 2
Current Direction . Sensor	Hydrc Products	659834	465-A	Mode 2
	LOWER	LOWER ASSEMBLY		
Unit Type	Manufacturer	Serial#	Wode1#	Utilization
Hydrophone 1	NUS Corporation	1415	1125	Mode 1
Hydrophone 2	NUS Corporation	1414	1125	Mode 2
Temperature Probe	Gulton Industries	27355	MET-2	Mode 2
Current Speed Sensor	Hydro Products	658949	460	Mode 2
Current Direction Sensor	Hydro Products	659948	465-A	Mode 2